The Climate Change Policy Regime and Information Networks in the United States Congress

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Abstract

Policy subsystems have long been the major unit of analysis for scholars of the policy process. However, recently scholars have noted that many vexing policy issues span the traditional boundaries of subsystems and operate in a trans-subsystem space where multiple subsystems are linked by institutional arrangements and a common policy issue. These types of governing arrangements have been termed policy regimes. Global climate change is just such a vexing issue; it spans multiple policy areas and contains a high degree of complexity. The type of policy regime that structures a policy issue can have implications for the types of policies that are adopted (or not) to address the issue. Using data from congressional hearings about climate change since 1976, I establish the structure of the information network within the climate change policy regime at the federal level. Specifically, using network analysis I determine the connections between the subsystems, congressional committees, and policy actors that make up the climate change policy regime. The findings suggest that the climate change information network consists of a core-periphery, with a few core congressional committees and witnesses, as well as a set of committees and witnesses on the periphery.

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1 Introduction

Climate change is one of the most pressing and complex issues facing governments around the world. As a result of this complexity, multiple interests and institutions need to be aligned to make climate policy possible. Policy making is traditionally understood to occur within semi-autonomous subsystems of actors and institutions often far removed from macro politics. Actors and institutions within these subsystems are connected through policy networks that are structured around information, resource, or authority exchanges. Moving beyond subsystems, recent work has noted that some policy issues, such as climate change, are *boundary-spanning* and display *trans-subsystem* dynamics (Jochim and May 2010; M. D. Jones and Jenkins-Smith 2009; May, Jochim, and Sapotichne 2011). These types of issues cut across the traditional bounds of subsystems, with networks that reach across several seeming disparate policy domains. Given the nature of these types of issues, effective responses require strong policy regimes.

A policy regime integrates governing arrangements–ideas, interests, and institutions–that span multiple subsystems. A coherent policy regime would have shared ideas, stable set of interests, and contained with a few policy venues (May and Jochim 2013). A large part of the coherence of a policy regime is found within the network of actors and institutions involved in the various decision-making processes (Orr 2006). Of particular importance for decision-making is information, as information helps to shape the ideas that are part of the foundation of a policy regime. Information for policymaking comes in many forms such as scientific and technical; policy analysis and evaluation; and expectations concerning the political consequences of particular policy decisions. Given the importance of information for policy regimes, understanding the nature of the information network involved in complex and divisive issues like climate change is needed.

In this paper, I examine the structure of the information network associated with climate change decision-making at the federal level in the United States. In particular, the sources of information that Congress gathers about climate change are examined. Overall, I find that the information network is structured by a core set of congressional committees and actors including the energy and environmental committees in the House and Senate, as well as scientific and technical experts; environmental interest groups; and utility companies that appear as witnesses at congressional hearings.

2 Policy Subsystems, Networks, and Regimes

Policy choices are typically made by semi-autonomous actors and institutions organized around specific policy domains that operate in parallel and exist outside the spotlight of macro politics (Baumgartner, Jones, and Mortensen 2014; Thurber 1996). The actors involved include those from government, as well as the private sector and interest groups. The institutions include the various policy venues where choices are made such as congressional committees and executive agencies. A number of terms have been used to describe the constellations of actors and institutions that determine policy within specific domains, but the two most prominent terms are policy subsystem and policy networks. Subsystems and networks are similar in the way that they focus on specific actors and institutions involved in particular policy areas, however they differ in that subsystems are organized by policy domain or issue, whereas policy networks are organized by the relationships between actors (Adam and Kriesi 2007; Weible and Sabatier 2005). Given the focus on relationships between actors for policy networks, multiple types of networks can exist within the same policy subsystem (Knoke 2011). The types of policy networks that exist within subsystems are based on their structure and function. Examples of the different types of networks include resource exchange, both voluntary and mandated; information signalling, where the network is based the transmission of information; and power relations, which include vertical networks and principal-agents relationships (Knoke 2001).[1] The nature of the policy networks are likely a function of the types of subsystem in which the networks are embedded.

Policy subsystems types can be thought to vary on a continuum from "iron triangles" that have limited participation–typically only the relevant government agencies, congressional committees, and private sector interest groups–on one end, to open and more pluralistic subsystems that include multiple policy actors and decision venues on the other (McCool 1998; Thurber 1996; Worsham 1998). Iron triangle and unitary type subsystems are likely to be less fragmented, share a common issue definition, and have fewer and more highly dense networks than pluralistic subsystems. Subsystems that are more open tend to have a higher number of actors, more policymaking venues, and sparse networks with hollow-cores (Heinz et al. 1990). Finally, the collaborative or adversarial nature of the subsystem is also likely to influence the type of policy networks that develop within a subsystem (Weible 2008).

Regardless of the type of subsystem, they are anchored by institutional arraignments and structured by the networks (i.e., linkages) between policy actors and institutions. One of the key institutional arraignments associated with subsystems are the various policymaking venues in which debate and decision-making occurs. Policymaking venues serve as a fulcrum around which policy debates and choice pivot. In the U.S. system Congress, through its committees, serve as the major venue providing the foundation for policy subsystems (Baumgartner and

[1] Weible and Sabatier (2005) also mention two other types of networks, ally and coordination networks.

Jones 1993; Fiorina 1989). Congressional committees anchor subsystems through the authority granted to them by Congress to consider legislation, collect information, and provide oversight of bureaucracies within the committees jurisdiction. The jurisdiction of a committee is based on policy domains (e.g., agriculture, defense, energy, labor) and these jurisdictions are mirrored across both chambers (Deering and Smith 1997).

2.1 Policy Regimes

More recently policy scholars have started to move beyond subsystems noting that many complex policy issues cross the, somewhat arbitrary, bounds of policy subsystems. Far from being completely autonomous, subsystems often overlap and/or linked by policy issues (M. D. Jones and Jenkins-Smith 2009; Zafonte and Sabatier 1998). Subsystems can become linked through salience disruptions, that can occur as a result of focusing events, or through policy dimension-shifts in which policy issues are redefined (M. D. Jones and Jenkins-Smith 2009). The linkage of subsystems is created by networks of policy actors and institutions that span multiple subsystems. The trans-subsystem dynamics associated with linked subsystems are useful in understanding issues like homeland security and climate change that have the potential to disrupt multiple subsystems.

Complex issues, such as climate change, that have the potential to impact multiple subsystems require a more coordinated response by policymakers to address the issue in an effective way. These types of issues give rise to the need for a policy regime (Jochim and May 2010; May and Jochim 2013). Policy regimes are a “governing arrangement that spans multiple subsystems and fosters integrative policies” (Jochim and May 2010, 307). The role of a policy regime is to provide an over-arching structure that makes coherent policy decisions to address boundary-spanning problems more likely (Worsham and Stores 2012). The governing arrangements within a policy regime include institutions, interests, and ideas. The institution arrangements provide structure for attention, information, and relationships (May and Jochim 2013). As with subsystems, congressional committees are the key part in organizing the various institutional arraignments within a policy regime. The interests in a policy regime consist of the various stakeholders that provide support or opposition to a regime (Orr 2006). Finally, ideas include the ways in which the policy regime issue is defined by the various interests and institutions involved.

Responding to complex issues requires the development of a strong policy regime, where strong regimes are defined by cohesion and coordination across different subsystems that may each have their own issue focus, actors, and venues. A policy regime with the capacity to address complex issues would foster legitimacy, policy coherence, and have a high level of durability (May and Jochim 2013). Examining the homeland security regime, May, Jochim, and Sapotichne (2011) find it to be "anemic" with no unifying definition of homeland security, varied involvement of interests, and a lack of clear institutional jurisdiction. In addition, LaPira (2014) found that the establishment of the homeland security regime failed to dislodge many long-term interest groups from their subsystem, while at the same time mobilizing new interest groups to become involved in the policy regime. A lack of a shared issue definition, disjointed interest mobilization, and fuzzy jurisdictional boundaries serve to limit the legitimacy, coherence, and durability of a policy regime, thereby calling into questions its ability to address "wicked" problems.

Ideas play a critical role in the formation and development of policy regimes, and ideas are formed and codified through the gathering and processing of information. Information for policy decision-making is processed within a policy subsystem and is transmitted through the information network within that policy subsystem. Therefore, the linkage of information networks across subsystems can have important implications for the development of policy regimes. Specifically, examining the structure of trans-subsystem information networks within policy regimes allows for insights into the provision and processing of information by actors and institutions and the subsequent ideas that might develop as a result of the information network structure. In addition, applying the techniques of social network analysis can highlight the key actors and institutions involved. The next section discusses information and information networks in the policy process.

2.2 Policy Regimes and Information Networks

Information in the policy process can consist of multiple types and serve many functions. The types of information can include science and technical knowledge, policy analysis, and policy narratives (Jenkins-Smith et al. 2014; M. D. Jones and McBeth 2010; Workman and Shafran

2015). The functions that information can perform in the policymaking process include knowledge development, problem solving, development of political strategies, and enlightenment over time (Weiss 1979).

Despite its importance, the understanding of the role of information in policymaking is evolving. Using reasoning from economics, one school of thought holds that information is *under-supplied* by bureaucrats and other policy experts so that they are advantaged in policy debates (e.g., Niskanen 1971). In addition, policymakers have been thought not to know the true "type" (i.e., preferences) of the experts providing the information. Under these conditions, the transaction costs associated with information gathering are high, therefore policymakers work to design the proper incentives so that experts will reveal information.

Rather than information being hidden, work by policy scholars has noted that information tends to be *over-supplied* in the policymaking process (Baumgartner and Jones 2015; Jones and Baumgartner 2005; Workman and Shafran 2015). These scholars note that policymakers receive information from multiple sources all trying to influence the policy process. The over-supply of information becomes more likely in pluralistic political systems with multiple policy actors and redundant systems of information gathering.

The supply of information is connected to the types of information search in which policymakers engage. One type of search is related to defining the issue or problem, and the other type of information search is related to solving the problem (Workman and Shafran 2015). The type of search connected to issue definitions has been termed *entropic* search, and it is the type of information that tends to be over-supplied (Baumgartner and Jones 2015). The over-supply of information for issue definition results from actors wishing to define an issue in a certain way to gain an advantage in the policy debate. Entropic information is most often used for knowledge development and enlightenment.

A second type of information search has been termed *expert* search and is connected to the type of information that is needed to apply solutions to problems that have been defined. Indeed, expertise in the policymaking process has been defined as the ability to connect policy design choices to policy outcomes (Callander 2008; Esterling 2004). Due to the costs associated with the development of expertise, expert information tends to under-supplied in the policy process. Expert information is most often used for problem-solving.

Regardless of the type or function of information, the supply and prioritization of information occurs within policy subsystems (Workman and Shafran 2015; Workman, Jones, and Jochim 2009). In particular, the supply and processing of information within subsystems is determined by the structure of the information network within that policy subsystem. Information networks have the potential to play a key role in subsystem, and by extension policy regime, development. Information networks consist of the actors and institutions that provide, gather, and process information within or across policy subsystems. Congressional committees are the key to the organizing and prioritization of information within subsystems (Krehbiel 1991; Workman and Shafran 2015). In particular, congressional hearings are a way for Congress to gain information, as well as a way for scholars to identify relevant subsystem actors (Burstein and Hirsh 2007; Diermeier and Feddersen 2000; Gormley 1998; May, Koski, and Stramp 2014; May, Sapotichne, and Workman 2009; Nowlin 2016). The next section discusses the nature of information processing about climate change by Congress.

2.3 Climate Change Information Networks in Congress

Climate change is a scientifically and socially complex issue, and Congress relies on multiple streams of information about climate change including reports from its agencies (Auer and Cox 2010), as well as hearings (Liu, Lindquist, and Vedlitz 2011; Liu et al. 2015; Park, Liu, and Vedlitz 2014). Much of the research examining congressional testimony has found that scientific information that supports the scientific consensus of anthropogenic climate change is well represented (Liu et al. 2015), although some variation exists in information based on the partisan make-up of Congress (Fisher, Leifeld, and Iwaki 2013; McCright and Dunlap 2003; Park, Liu, and Vedlitz 2014). For example, Fisher, Leifeld, and Iwaki (2013) found that views challenging the science of climate change were more prominent in a Republican controlled Congress than one controlled by the Democrats. Much of the differences can be traced to the sources of information from which the parties draw when they control Congress. For the most part, Republicans tend to draw on a more diverse set of witnesses (Park, Liu, and Vedlitz 2014), particularly those from the private sector. Democrats tend to rely on environmental groups and executive branch agencies (Fisher, Leifeld, and Iwaki 2013).

While some work has examined the partisan nature of climate change related information, less work has examined the structure of the information network concerning climate change. An exception is Park, Liu, and Vedlitz (2014), which explored three types of networks with regard to climate change hearings in Congress including an issue focus network, a sector mobilizing network, and a framing network. However, the analysis focused on the impacts of partisan control of Congress on each type of network rather than the overall structure of the committees and witnesses providing and processing information. The trans-subsystem nature of climate change makes the structure of the information network important for the emergence of a climate change policy regime. The key components of the information network structure are the providers of the information to Congress and the committees that process that information. In particular, does the information network have a "hollow-core", or does it have a strong core consisting of a few committees and actors (Grossmann 2013; Heinz et al. 1990). Given the multiple subsystems that climate change intersects (M. D. Jones and Jenkins-Smith 2009), it is possible that the climate change information network exhibits the characteristics of a hollow-core network, with few central actors and institutions. However, given the scientific nature of climate change the information network could also have a strong core network of scientists and other experts.

An additional consideration for the information network is the type of information search with which it is associated. An information network focused on entropic search would likely be less centralized and have multiple actors and institutions involved. Whereas, a network structured for expert information would likely have a strong core of scientists and other experts appearing before only a few congressional committees.

Finally, subsystems are where the information processing occurs, therefore the structure of the information network is also dependent on the subsystems involved. According to the Environmental Protection Agency, the sectors that produce the most greenhouses gasses (GHG) are electricity (31%), transportation (27%), industry (21%), commercial / residential (12%), and agriculture (9%).[2] Therefore, it is possible that the committees and actors within those various subsystems (e.g., domestic energy production, transportation, agriculture) participate in the climate change information network in proportion to their GHG emissions.

These considerations set-up several hypotheses about the structure of the climate change information network. Specifically, there are competing hypotheses about the core-periphery nature of the network with one expectation being that a weak core exists given the trans-

[2] see `https://www3.epa.gov/climatechange/ghgemissions/sources.html`

subsystem dynamics of climate change. An alternate expectation is that a strong core exists given the scientific and technical basis of climate change. Related to the core-periphery structure is the type of search in which the network engages, a strong core of scientists and experts would indicate expert search, whereas a hollow-core would indicate entropic search. Finally, subsystem participation is likely a function of the GHG emissions of the various sectors, so it is expected that sectors that produce more GHG will be more represented in the climate change information network. The next section describes the data and approaches used to examine these conjectures.

3 Data and Methods

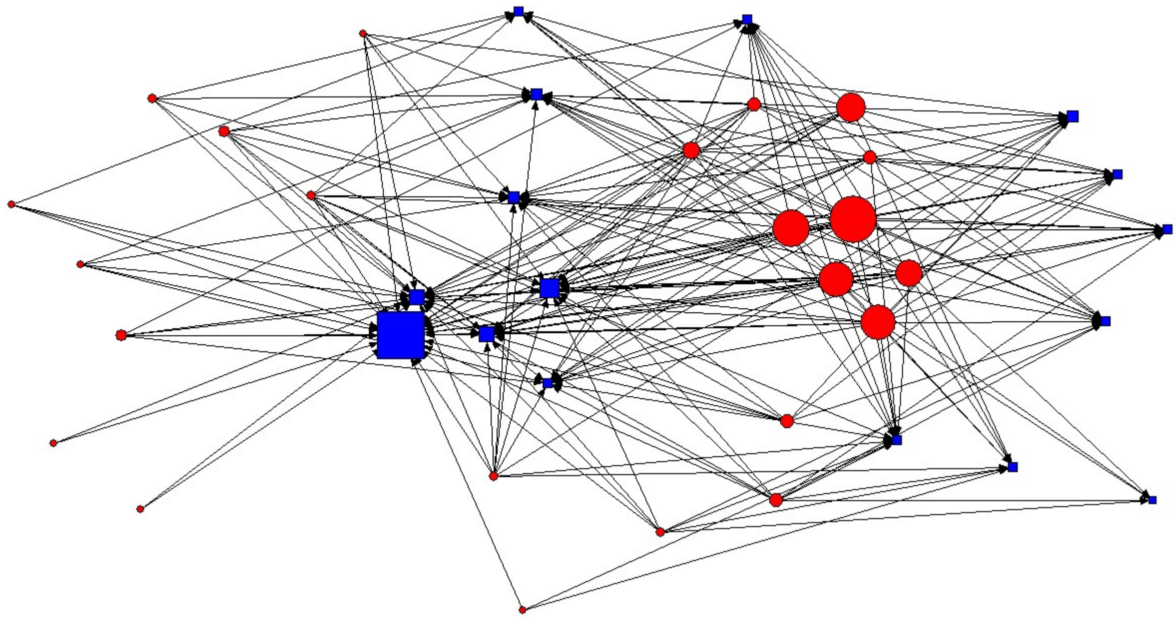
To examine the nature of the climate change information network, congressional hearings were utilized. Hearings are often used by policy scholars to determine subsystem participation (May, Sapotichne, and Workman 2009; Nowlin 2016). In addition, congressional committees are the "keystone" policymaking institution and play a large in anchoring subsystems (Fiorina 1989). One of the functions of congressional committees is to gather information relevant to policy decision-making. Therefore, analyzing the congressional committees and witnesses involved in climate change deliberations allow for the examination of how the information network is structured.

The *ProQuest Congressional* database was used to find congressional hearings that dealt with climate change. The search terms used were "Climate Change", "Global Warming", and "Greenhouse Gas." The results showed that 348 hearings occurred between 1976-2014, with a total of 2,364 witnesses. Data gathered about each hearing included the Congress, year, title, committee, subcommittee, witnesses, and witness affiliation. The data collected here builds on previous work (e.g., Park, Liu, and Vedlitz 2014) by adding more recent hearings as well as a more precise coding of witnesses that appeared at each hearing by affiliation, particularly private sector witnesses. In addition, network analysis techniques are used to examine the structure of the information network. Descriptive statistics for the committees and witnesses are below.

3.1 Climate Change Information Network

Using the methods of network analysis allows for the examination of the relationships between actor and institutions within and across policy subsystems. In the following analysis, I explore the nature of the information network, specifically the sets of actors and congressional committees that provide and process information about climate change through congressional hearings. Figure 1 displays the full two-mode network, where one node represents committees and the other node represents witnesses involved in climate change hearing from 1976-2014. For purposes of this analysis, data are pooled across years to examine the entirety of the climate change information network.[3]

Figure 1: Complete Information Network



In Figure 1 the red circle nodes represent the committees and the blue square nodes represent the witnesses. The size of the nodes reflects the number of hearings that the committee held (for red circles) and the number of witnesses from each category (for the blue squares). The edges represent the geodesic distance between the nodes. As can be seen, there are few larger circles that represent the committees that held the most hearings, as well a few larger squares that represent witnesses that appeared more times as witnesses. The densest part of the network is represented by the larger nodes at the center of the graph, however several smaller nodes are also present. The next section identifies the nodes representing the congressional committees, followed by the witnesses.

Table 1 shows the congressional committees that held at least three hearings regarding

[3]Network graphs and analysis was performed using *UCINET* software.

Table 1: Climate Change Hearings by Committee: 1976-2014

Committee	Chamber	Number	Percent
Agriculture	House	5	1.44
Agriculture, Nutrition, and Forestry	Senate	9	2.59
Commerce, Science, and Transportation	Senate	31	8.91
Energy and Commerce	House	59	16.95
Energy and Natural Resources	Senate	43	12.36
Energy Independence and Global Warming	House	34	9.77
Environment and Public Works	Senate	45	12.93
Finance	Senate	8	2.30
Foreign Affairs	House	9	2.59
Foreign Relations	Senate	11	3.16
Homeland Security and Governmental Affairs	Senate	4	1.15
Natural Resources	House	10	2.87
Oversight and Government Reform	House	15	4.31
Science and Technology	House	42	12.07
Small Business	House	7	2.01
Transportation and Infrastructure	House	3	< 1
Ways and Means	House	5	1.44

$\chi^2 = 448.012$, significant at $p < .001$

climate change from 1976 to 2014.[4]

As can be seen, the Energy and Commerce committee in the House held the most hearings with 59, or nearly 17% of all climate change hearings, followed by Energy and Natural Resources; Environment and Public Works; and Science and Technology each with about 12 to 13 %. Those committees represent the largest circle nodes in Figure 1. The remaining committees held less than 10% of all hearings. The χ^2 of 448.011 is significant at $p < .001$.

Witness that appeared at hearings addressing climate change were coded by their affiliation and aggregated into one of several categories. Categories include *Government* such as federal agencies, members of Congress, state and local governments. *Interest groups* include environmental groups (e.g., Sierra Club, NRDC), unions, and the chamber of commerce. *Experts* are witnesses representing academic or research oriented institutions, or professional associations. *International* includes witness from outside the United States such as representatives from other governments. Witnesses from the private sector, including businesses and trade associations, were coded based on the North American Industry Classification System (NAICS). The eco-

[4]Several economic / finance committees held less than three hearings including the House Appropriations committee, the Budget committee, the Financial Services committee, and the Small Business and Entrepreneurship committee that held one hearing each. In addition, the Banking, Housing, and Urban Affairs committee and the joint Economic committee each held two.

Table 2: Climate Change Hearings and Witness Affiliation: 1976-2014

Witness	Number	Percent
Government		
Federal Agencies	512	21.66
Members of Congress	66	2.79
State and Local	153	6.47
Total Government	**731**	**30.92**
Private Sector		
Agriculture	61	2.58
Manufacturing	83	3.51
Mining	48	2.03
Transportation	46	1.96
Utilities	233	9.86
Other Industries	69	2.92
Total Private Sector	**540**	**22.86**
Interest Groups		
Environmental	166	7.02
Other Interest Groups	69	2.92
Total Interest Groups	**235**	**9.94**
Experts	**761**	**32.19**

χ^2 = 4228.6, significant at $p < .001$

nomic sectors include Agriculture, Forestry, Fishing and Hunting (NAICS 11), Manufacturing (NAICS 31-33), Mining, Quarrying, and Oil and Gas Extraction (NAICS 21), Transportation and Warehousing (NAICS 48-49), and Utilities (NAICS 22). Table 2 presents the number and percent of witnesses.

As can be seen, witnesses classified as experts totaled 761 and represented roughly a third of all witnesses (32.19%). In Figure 1, experts are the largest square node. Government witnesses, 731, also represented nearly a third (30.92%) with federal agencies accounting for 21.66% percent of government witnesses. In total, private sector witnesses represented 22.86% of all witness, with the utilities sector accounting for the largest percent of private sector witnesses at 10%. Given the predominance of experts and government agencies, these results point to a more expert based rather than an entropic based information search. The χ^2, 4228.606, is significant at $p < .001$. Table 3 further breaks down the two largest categories of witnesses; experts and federal agencies.

Federal agencies with the highest number of witnesses are listed including the Environmental Protection Agency (EPA) which accounts for 18.16% of federal agency witnesses. The EPA is

Table 3: Federal Agencies and Experts

(a) Federal Agencies

Agency	Number	Percent
DOE	74	13.19
EPA	93	18.16
NASA	44	8.59
NOAA	65	12.70
State Dept.	42	8.20
USDA	14	2.73
Other Agency	181	32.26

(b) Experts by Affiliation

Affiliation	Number	Percent
National Academy	80	10.51
National Laboratory	46	6.04
Professional Association	23	3.02
Research Institute	176	23.13
Think Tank	97	12.75
University	319	41.92
Other Affiliation	20	2.63

followed by the Department of Energy with 13.19% and the National Oceanic and Atmospheric Administration (NOAA)[5] at 12.10% of federal agency witnesses. Looking next at experts, the largest percent of expert witnesses, 41.92%, had a university affiliation followed by those from a research institute (e.g., Woods Hole) with 23.13%. Think tanks are next with 12.75%, and they are coded as think tanks if they have an advocacy or ideological orientation rather than pure research (e.g., CATO Institute, Heritage Foundation, Center for American Progress).

Overall, a pattern of information collection and processing can be seen. Regarding the congressional committees involved, they are centered around the energy, environment, and science based committees in the House and the Senate. However, a number of other committees that represent various policy jurisdictions (e.g., agriculture, foreign affairs, and transportation) are also represented. This points towards a core-periphery network structure, rather then a hollow-core structure. In addition, witnesses are largely drawn from government and experts, indicating that for the majority of congressional information gathering regarding climate change may have been based on expert, as opposed to, entropic search. The next section uses the tools of network analysis to more closely examine the climate change information network.

In examining the information network associated with climate change, one of the key questions is to establish the key conduits of information processing. The analysis discussed above showed that information related to climate change was processed largely by four congressional committees, Energy and Commerce; Environment and Pubic Works; Energy and Natural Resources; and Science and Technology. The analysis also showed that the witnesses providing information were largely scientific and technical experts and drawn from various levels of gov-

[5]NOAA is part of the Department of Commerce, however given its leading role in climate science it was coded separately.

ernment. However, the overall participation numbers don't provide the clearest picture of the importance of the committees or the witness in the overall network. One of the key concepts in network analysis is centrality, which involves the numbers of connections that an actor has to others in the network. An actor that is more "central" would have a greater number of connections. Degree, one of the prominent measures of centrality, can provide evidence for the importance of an actor within a network. Degree centrality measures the number of connections a node has within the network (Knoke and Yang 2008). In a two-mode network, the degree is the number of ties a node has with members of the other node set. The degree measure is typically normalized and ranges from 0 to 1. For congressional committees, a degree value of 1 would indicate that the committee saw witnesses from each category of witnesses, and for witnesses a degree value of indicates that witnesses from that category appeared in front of every committee. Figure 2 plots the degree centrality scores for committees and witnesses.[6]

For the committees, shown in Figure 2a, the House Science and Technology committee has a degree score of 1, indicate that witnesses for each category testified before that committee. This result places the Science and Technology committee in a more central role in information gathering than the earlier analysis would have suggested. The next set of key committees include the Environment and Public Works committee; the Energy and Natural Resources committee; the Energy and Commerce committee; and the Commerce, Science, and Transportation committee, which each saw witnesses from all but one category.

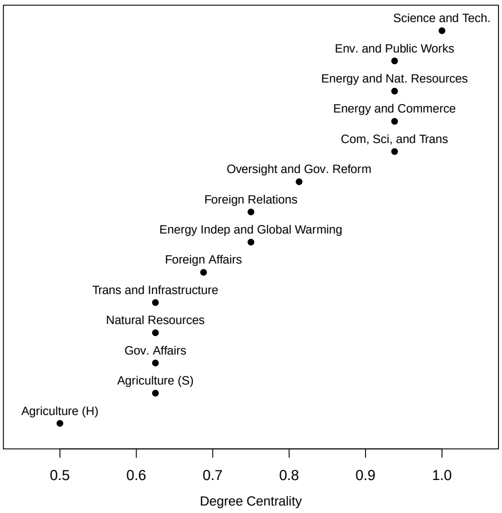
As noted, the evidence thus far seems to suggest that the climate change information network exhibits a core-periphery structure. A core-periphery network structure implies a small set of "core" actors with strong ties as well as other actors that are loosely connected. Network types has been shown to vary across policy areas, with environmental policy demonstrating a core-periphery structure (Grossmann 2013). Table 4 shows the density, where density in a two-mode network is the average number of connections between nodes in different sets, and the most prominent committees and witnesses in both the core and the periphery.

As shown, the core network consists of the Environment and Public Works; Energy and Natural Resources; and the Energy and Commerce committees, as well as expert witnesses, those from the utilities sector, and environmental groups. The periphery committees and witnesses include the various economic committees (e.g., Budget, Finance, Ways and Means) as well as

[6]Note that for committees only those with a degree < 0.50 are shown.

Figure 2: Committee and Witness Degree Centrality

(a) Congressional Committees



(b) Witnesses

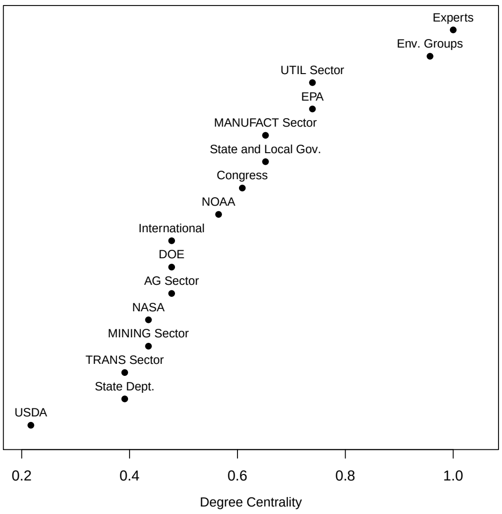


Table 4: Core-Periphery Structure of the Climate Change Information Network

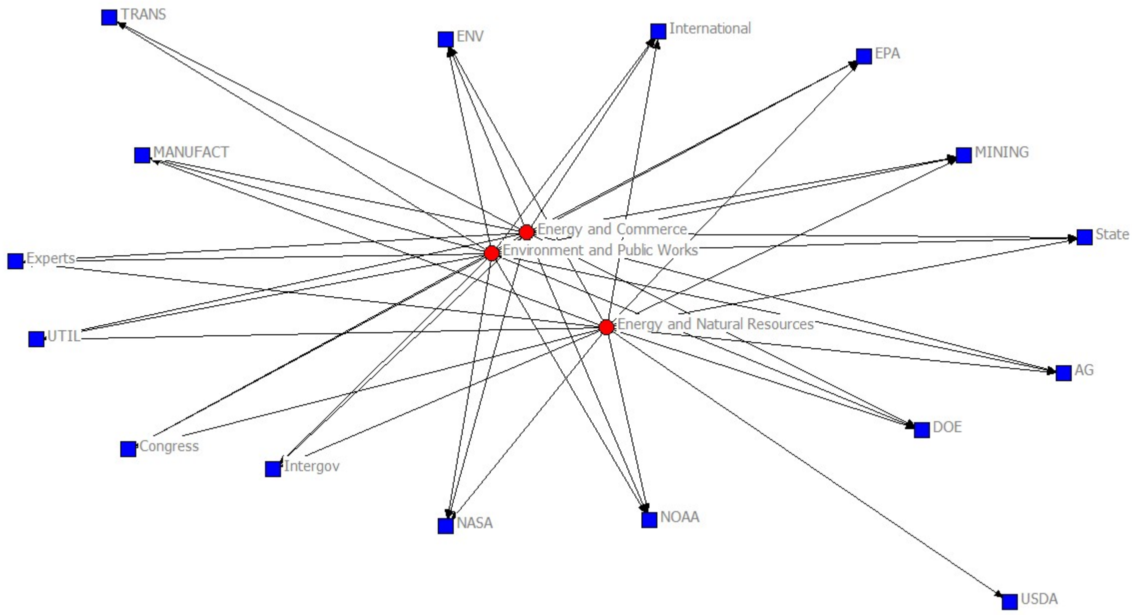
	Density	Committees	Witnesses
Core	65.33	EPW, ENR, EC	Experts, Utilities, ENV
Periphery	1.752	AG, Economic	AG Sector, USDA

The fit measure is 0.819

the agriculture committees. The agriculture sector witnesses were also on the periphery, as was the Department of Agriculture. The core-periphery network analysis fitness measure is normalized from 0 to 1, and a value closer to 1 indicates a closer approximation to the idealized core-periphery structure. The fitness measure is 0.819, indicating a clear core-periphery network structure.

Figure 3 illustrates the congressional committees that make up the core of the information network, as well as the witnesses that appear in hearings held by those committees.

Figure 3: Core Information Network



3.2 Subsystems and Information Networks

One of the major features of a policy regime is that it encompass multiple subsystems that each have their own array of actors and institutions. The trans-system dynamics of climate change cut across several subsystems that are GHG producers including agriculture, energy, and transportation. However, despite the multiple subsystem dynamics there exists a core information network for climate change. To future explore the subsystem characteristics of the core-periphery network, I examine several measure of centrality associated with various committees that structure the different policy subsystems. Table 5 shows the centrality measures for the committees associated with various subsystems, as well as the witnesses that appeared most often in the hearings that those committees held, excluding experts.

Table 5: Policy Subsystems and the Climate Change Information Network

Subsystem	*Centrality Measures*			*Witnesses*	
	Degree	Closeness	Eigenvector	Fed. Agencies	Other
Agriculture					
House Committee (AG)	0.500	0.789	0.159	USDA	AG
Senate Committee (ANF)	0.625	0.833	0.197	USDA	AG, ENV
Energy					
House Committee (EC)	0.938	0.968	0.297	DOE, EPA	UTIL, ENV, Intergov
Senate Committee (ENR)	0.938	0.968	0.292	DOE, EPA	UTIL, ENV
Transportation					
House Committee (TI)	0.625	0.833	0.214	DOT	TRANS, Intergov

The energy subsystem is clearly the most central with the associated congressional committees having higher values on each of the centrality measures. As noted, in a two-mode network degree centrality is the number of ties an actor in one mode has with actors in the other mode. Closeness is the sum of geodesic distances from a node to all others, and is normalized so that a higher score means a greater level of centrality. Therefore, congressional committees that are outside the core would have a lower closeness score, which indicates a further distance from witnesses. Eigenvector centrality accounts for the connections that a node has to other nodes that are strongly connected in the network. A high eigenvector score indicates that the node is connected to other nodes that have many connections.

As can be seen, energy is the most central core subsystem. The energy subsystems committees saw ~ 94% of the witness categories, as well as having a higher level of closeness, and a higher eigenvector. The committees associated with the agriculture and transportation subsystems has roughly equivalent levels of centrality. Overall, it seems that the transportation subsystem is represented less than would be expected in the information network given the GHG emissions of the transportation sector.

4 Discussion and Conclusion

Addressing complex issues such as climate change require a strong policy regime that effectively integrates policy goals across multiple policy subsystems. A major component of regime integration is the structure of the various networks that link actors within and across subsystems. The information network of a policy regime is particularly important given that shared ideas are a major part of the foundation of a policy regime.

This paper examined the structure and characteristics of the climate change information network at the federal level. Overall, the network exhibited a clear core-periphery structure with a strong core represented largely by the energy subsystem which includes the Energy and Commerce; Energy and Natural Resources; and the Environment and Public Work committees. The actors included in the core are experts, representatives of the utilities sector, and environmental interest groups. The strong presence of experts in the core illustrate that overall, committees were broadly engaged in expert rather than entropic information search. However, the type of search is likely to vary over time. The presence of a strong core could make the development of a climate change policy regime, however periphery actors and institutions can act as veto points and/or alternative policy venues, making the development of an integrative climate change regime in the US more difficult.

Future research should examine the content of the information provided by witnesses as congressional hearings concerning climate change. The informational content is likely to vary over time and by party control of Congress (as shown in Fisher, Leifeld, and Iwaki 2013; and Park, Liu, and Vedlitz 2014). Also, work is needed to understand the dynamic nature of information network development, particularly how the structure of the network changes over time as different dimensions of the climate change debate are considered.

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